Machine learning for shock decision in implanted defibrillators

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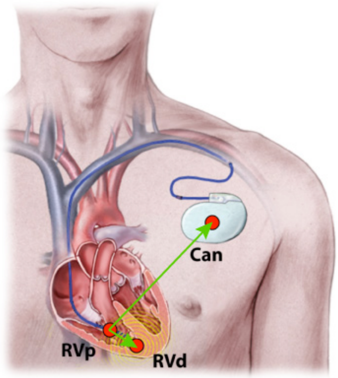
The discrimination of Ventricular Tachycardia (VT) from Supra-Ventricular Tachycardia (SVT) remains a major challenge for appropriate therapy delivery in Implantable Cardioverter Defibrillators (ICDs). Unlike SVT, VT is a life-threatening arrhythmia that may lead to sudden death unless an appropriate shock is delivered. The discrimination in ICDs is performed from endocardial measurements of the electrical activity of the heart (EGM). Historically, only time intervals extracted from EGMs were used for the diagnosis. In the last decade, an additional analysis of features extracted directly from the shape of a single EGM channel led to improved performances, especially in order to avoid inappropriate shocks, which are very painful and stressful for patients. A recent study shows that inappropriate shocks occurred in 11.5% of the prophylactic ICD patients and accounted for 31.2% of the total shock episodes [1].

The discrimination method proposed here relies on the simultaneous analysis of two different ventricular EGM channels, available in most common implanted defibrillators. Therefore, we have designed a two-dimensional representation of both a far-field (RVp-Can) and a near-field (RVp-RVd) EGM signals (Figure 1), named "Spatial Projection Of Tachycardia electrograms" (SPOT) (Figure 2). The SPOT curve of a cardiac cycle is the plot of the amplitude of the far-field sensing signal versus the amplitude of the near-field sensing signal, with time as a parameter. Features extracted in this space representation allow curve comparison. The underlying assumption is that the morphology of an SVT SPOT curve is similar to that of the reference curve constructed from the patient's normal EGMs, while the SPOT curve for a VT is different (Figure 2): this is justified by the fact that the electrical signals pertaining to normal heartbeats and to SVT heartbeats originate from the atria and follow the same electrical conduction pathway to the ventricles, while VT electrical signals, originating from the ventricles, have a different activation pattern, leading to a change in the morphology of the signals received by the electrodes.

Morphological features are extracted from the curves, and candidate features for statistical classification, based on physiological prior knowledge, are computed to compare arrhythmia and reference SPOT curves: the average angle of the relative velocity vectors, the correlation coefficient between the norms of the velocity and the correlation coefficient between their curvatures. These three features, and two additional timing descriptors, form a set of candidate features, on which statistical feature selection was performed by the random probe method [2]. Classifiers of various types and complexities (Linear, Polynomial, Neural networks, Support Vector Machines) were subsequently trained. Model selection was carried out by leave-one-out.

SVM classification on a data base of 93 VT and 26 SVT from 73 patients provided 95.7% sensitivity and 92.3% specificity. Therefore, a substantial improvement in sensitivity and specificity is expected of SPOT-based discrimination algorithms for VT/SVT discrimination, which should result in a more comfortable therapy and an improved quality of life for defibrillator-implanted patients.



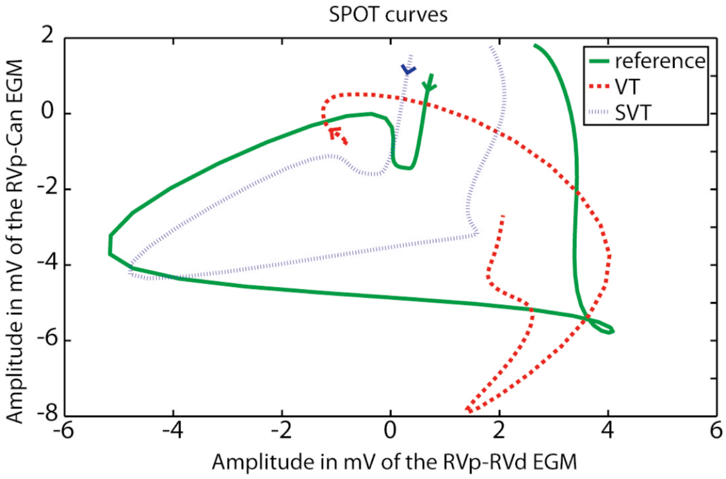


Figure 1: ICD system and EGM signals

Figure 2: SPOT curves

References

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Topic: Visual processing and pattern recognition

Preference: Poster